Claims

What is claimed is:

1. A method of making crystals, comprising:

suspending a porous preform made of a crystal raw material in a hermetically-sealed chamber;

heating the porous preform to a selected treatment temperature that enables reaction between a fluorinating agent and oxide impurities in the porous preform;

reacting the fluorinating agent with the oxide impurities at the selected treatment temperature for a selected time period;

forming a melt from at least a portion of the porous preform;

filling a crucible in the hermetically-sealed chamber with the melt; and

progressively moving the melt through a temperature gradient zone defined inside the hermetically-sealed chamber to grow one or more crystals.

2. The method of claim **1**, wherein the hermetically-sealed chamber is provided by a hermetically-sealed muffle furnace made of a non-porous refractory material.

3. The method of claim **2**, wherein the non-porous refractory material comprises one selected from the group consisting of quartz, alumina, silicon carbide, vitreous carbon, vitreous graphite, glass carbon-coated graphite, and combinations thereof.

4. The method of claim **1**, wherein the fluorinating agent is in gaseous form and is selected from the group consisting of CF_4, NF_3, SF_6, BF_3, C_2H_4, HF, F_2, and mixtures thereof, and similar fluorinating gases known in the art.

5. The method of claim **4**, wherein the fluorinating agent is supplied into the hermetically-sealed chamber in a stream of inert gas.

6. The method of claim **4**, wherein the pressure in the hermetically-sealed chamber while reacting the fluorinating agent with the porous preform is in the range of 0.1 to 5 atm.

7. The method of claim **4**, wherein the porous preform is heated to a treatment temperature in the presence of an inert gas prior to exposing the porous preform to the gaseous fluorinating agent.

8. The method of claim **1**, wherein reacting the fluorinating agent with the oxide impurities comprises removing volatile gases formed during reaction of the fluorinating agent with the oxide impurities from the hermetically-sealed chamber, and wherein forming the melt occurs in an inert atmosphere.

9. The method of claim **1**, wherein the fluorinating agent is in solid form and mixed into the crystal raw material in a range from 0.5 to 2 wt%.

10. The method of claim **1**, wherein progressively moving the melt occurs in an inert atmosphere or vacuum.

11. The method of claim **1**, wherein the crystal raw material comprises a metal fluoride selected from the group consisting of CaF_2, BaF_2, MgF_2, SrF_2, LiF, NaF, $(M_1)_x(M_2)_{1-x}F_2$, and M_3AlF_6, and mixtures thereof; and where M_1 is selected from the group consisting of Li, K, and lanthanide series metal fluorides; M_2 is selected from the group consisting of Ca, Ba, Mg, Sr, and lanthanide series metal fluorides; M_3 is selected from the group consisting of Li, Na, K, Rb, and Cs; and x is in a range from 0 to 1.

12. The method of claim **11**, wherein the crystal raw material further comprises a lanthanide series metal fluoride mixed with the metal fluoride.

13. The method of claim **1**, wherein the selected time period is in the range of 1 to 240 hours, and the selected treatment temperature is dependent on the melting point of the crystal raw material and is in the range of 50 to 500 °C below the melting point of the crystal raw material.

14. An apparatus for making crystals, comprising:
a hermetically-sealed muffle furnace made of a non-porous refractory material;
at least one port for entry and exit of gaseous substance within the muffle furnace;
at least two temperature-controlled zones defined inside the muffle furnace;
a crystal growth crucible disposed inside the muffle furnace;
an actuator operable to translate the crucible along a length of the muffle furnace; and
means for suspending a porous preform above the crucible.

15. The apparatus of claim **14**, wherein the non-porous refractory material comprises one selected from the group consisting of quartz, alumina, silicon carbide, vitreous carbon, vitreous graphite, glass carbon-coated graphite, and combinations thereof.

16. The apparatus of claim **14**, wherein the crucible is made of a non-porous refractory material selected from the group consisting of quartz, alumina, silicon carbide, vitreous carbon, vitreous graphite, glass carbon-coated graphite, and combinations thereof.

17. The apparatus of claim **14**, wherein the at least one port is provided in an end cap fitted in sealed contact at an end of the muffle furnace, and wherein the cap is made of a non-porous refractory material selected from the group consisting of quartz, alumina, silicon carbide, vitreous carbon, vitreous graphite, glass carbon-coated graphite, and combinations thereof.

18. The apparatus of claim **14**, wherein the actuator is operable to rotate the crucible about the axial axis of the muffle furnace.

19. The apparatus of claim **14**, wherein the crucible comprises one or more crystal growth chambers stacked vertically.

20. The apparatus of claim **14**, wherein the temperature-controlled zones are defined by one or more heaters disposed external to the muffle furnace, one or more conductive portions of the muffle furnace, and combinations thereof.